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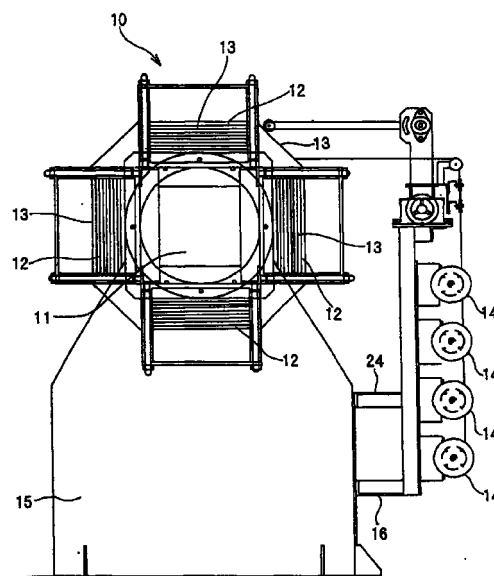
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(54) **METHOD AND DEVICE FOR THREE-DIMENSIONAL ARRANGEMENT OF WIRE AND
METHOD OF MANUFACTURING CONDUCTIVE MATERIAL**

(57) A method and apparatus (10) for three-dimensional wire alignment for manufacturing a wire structure wherein a wire (13) is three-dimensionally aligned at prescribed pitches. The method comprises steps of providing one or more border-like frame body (12) having a prescribed thickness peripherally of the rotary shaft (11), winding a wire (13) on the border-like frame body (12) at prescribed pitches so that the wire (13) surrounds the rotary shaft (11) and the border-like frame bodies (12) by rotating the rotary shaft (11), and repeating steps of stacking another set of border-like frame bodies (12) on the border-like frame bodies (12) and winding a wire (13) thereon at prescribed pitches. A wire structure having a wire aligned three-dimensionally and accurately at prescribed pitches may be manufactured.

FIG. 1



EP 1 065 017 A1

Description

Technical Field

[0001] The present invention relates to a method of three-dimensional wire alignment and an apparatus therefore for manufacturing a wire structure wherein the wire is aligned three-dimensionally at prescribed pitches, and also to a method of manufacturing electrically conductive materials such as a printed circuit board material or an anisotropic conductive material using the wire structure.

Background Art

[0002] Manufacturing a wire structure wherein an electrically conductive wire is aligned three dimensionally and accurately at prescribed pitches is an important technology for manufacturing an anisotropic conductive material comprising a wire structure embedded into rubber or resins. An anisotropic conductive material is used as a member for a printed circuit board material or the like wherein the electrodes on a device and on a distributing board are connected facing with respect to each other. In this case, electricity is conducted only between electrodes along the wires, and is insulated in the direction horizontally of the device or the distributing board. By taking advantage of such characteristics, an anisotropic conductive material has been widely used as a wiring member for calculator, liquid crystal, and so on.

[0003] The printed circuit board includes a slot for receiving an integrated circuit and a group of connecting terminals for variety of electronic components on one side, and a printed conductive path for connecting components on the other side, which has been traditionally used in quantity as a constituent member for electronic equipment.

[0004] Conventionally, a material used for printed circuit boards has been manufactured by the steps of manufacturing a plate body made of insulating materials such as epoxy resin or glass, forming a through hole for conduction of electricity at a prescribed location by drilling operation, coating the through hole for conduction of electricity with a conductive metal such as copper by means of plating operation, and then sealing the through hole with a sealing agent.

[0005] However, there are recognized disadvantages in that drilling on the plate body produces chip-pings during the process, which may lead to product defects, and that plating is subject to cracks at the edge portion of the board material, which may lead to faulty conductivity. In addition, the ratio of the length of the through hole (thickness of the board) to the diameter of the hole is limited to about 5 for drilling; the lower limit of diameters of a through hole for a board of 1mm in thickness will be about 0.2mm. However, smaller diameters are preferable for obtaining a printed circuit board of high densities, which has been difficult for drilling.

[0006] A circuit board manufactured by the steps of inserting electric wires such as Ni or Co into the frame body, pouring an insulating material such as molten epoxy resin or the like therein, cutting it along the plane perpendicular to the metal wires after the resin is hardened, and connecting both cut planes electrically is presented (see Japanese Unexamined Patent Application Publication No. 49-8759).

[0007] However, since an epoxy resin or the like is used in this circuit board, there has been a disadvantage in that accuracy in dimension such as a pitch of through holes may be impaired due to volumetric shrinkage of about 2 to 3% in the process of curing of the resin. This is a serious disadvantage since accuracy in dimension is a very important factor in a high-density printed circuit board.

[0008] In addition, in this type of circuit board, a difference of the thermal expansion between itself and the conductive layer laminated on one side or both sides thereof (photo process layer) is not considered, separation between a board material and the conductive layer may occur due to the impact applied during service or temperature variations. Separation may also occur between an insulating material and the metal wire.

[0009] In view of above described disadvantages of the prior art, it is an object of the present invention to provide a method of three-dimensional wire alignment and an apparatus used therefor that enables manufacturing of large size wire structures as well as miniature wire structures wherein a wire is aligned three-dimensionally accurately at prescribed pitches, and that ensures high productivity and facility of handling.

[0010] It is another object of the present invention to provide a method of manufacturing conductive materials such as a printed circuit board material or an anisotropic conductive material wherein satisfactory electrical conductivity is established and the thermal expansion property may be controlled so that separation between a board material and a conductive layer, and between an insulating material and a metallic line (wire) during service can be prevented.

[0011] It is still another object of the present invention to provide a method of manufacturing conductive materials that enables to obtain a printed circuit board material or an anisotropic conductive material with higher density and improved dimensional accuracy conveniently and easily with improved workability.

Disclosure of Invention

[0012] According to the present invention, there is provided a method of three-dimensional wire alignment (first method of alignment) for manufacturing a wire structure having a wire aligned three-dimensionally at prescribed pitches comprising steps of disposing one or more border-like frame bodies having a prescribed thickness peripherally of the rotary shaft, winding a wire on the border-like frame body at prescribed pitches in

such a manner that the wire surrounds the rotary shaft and the border-like frame body by rotating the rotary shaft, and repeating steps of stacking another set of border-like frame bodies on the above described border-like frame bodies and winding another wire thereon at prescribed pitches.

[0013] According to the present invention, there is also provided a method of three-dimensional wire alignment (second method of alignment) for manufacturing a wire structure having a wire aligned three-dimensionally at prescribed pitches comprising steps of disposing two separator plates each having a prescribed thickness on any one or two sides of the prism space keeping a prescribed distance apart, winding a wire on the two separator plates at prescribed pitches by rotating the prism space about the central axis thereof many turns, and repeating steps of stacking another set of separator plates on above described two separator plates and winding another wire thereon at prescribed pitches.

[0014] According to the present invention, there is further provided a method of three-dimensional wire alignment (third method of alignment) for manufacturing a wire structure having a wire aligned three-dimensionally at prescribed pitches comprising steps of building a mold either by disposing one or more border-like frame bodies having a prescribed thickness on its periphery or by disposing two separator plates having a prescribed thickness on any one or two sides of its periphery keeping a prescribed distance apart, winding a wire at prescribed pitches on the above described border-like frame body or the separator plates building the mold by moving the wire bobbin around the mold, and repeating steps of stacking another set of border-like frame bodies or separator plates on the above described border-like frame bodies or the separator plates and winding a wire thereon at prescribed pitches.

[0015] According to the present invention, there is also provided an apparatus for three-dimensional wire alignment (first apparatus of alignment) comprising two side plates disposed in the direction perpendicular to the axis of the prism space facing with respect to each other, two separator plates of a prescribed thickness disposed between the side plates on one or two sides of the prism space parallel with and spaced a prescribed distance from the axis of the prism space, a driving means for rotating these side plates and separator plates about the axis of the prism space defined by the side plates and the two separator plates, and a wire bobbin for feeding a wire to be wound thereon at prescribed pitches from the side of outer periphery of the two separator plates.

[0016] Preferably, in above described method and apparatus for three-dimensional wire alignment, V-shaped grooves are formed on the end surface of the separator plate at prescribed pitches for aligning wire three-dimensionally and accurately.

[0017] According to the present invention, there is provided an apparatus for three-dimensional wire align-

ment (second apparatus of alignment) comprising a wire feeding mechanism, a spacer and a guide block for straining a wire, a mold for fixing the spacer and the guide block, and a rotary mechanism for rotating the mold, characterized in that the groove portions for disposing the wire on the spacer at prescribed pitches are formed at prescribed pitches and prescribed depths, and that the guide block is provided with notched portions at prescribed pitches for defining the position of the wire and supporting the tensile strength of the wire.

[0018] Preferably, this apparatus for three-dimensional wire alignment is constructed in such a manner that the more the spacers and the guide blocks are stacked, the longer the distance between the spacer and the notch formed on the guide block becomes. It is also preferable that the apparatus is constructed in such a manner that the wire is strained between a plurality of groove portions located on a imaginary line extending almost straightly parallel with the stacking direction of the spacers and notched portions formed on a guide block when the spacers are stacked in prescribed multiple layers.

[0019] It is also preferable that the guide block is provided with a bevel portion corresponding to the straining angle of the wire for preventing contact between the wire strained from the guide block to the spacer and the portion of the guide block other than the notched portions. It is further preferable to form the bottom portion of the notched portion formed on the guide block in a profile having an obtuse angle or a curvature since it can prevent the wire from being broken due to extreme bending thereof.

[0020] When straining a wire, preferably, the wire feeding mechanism that can control the wire feeding position by sliding itself in the direction parallel to the rotary shaft of the rotary mechanism for rotating the mold is used and a plurality of wires may be fed to the mold at a time. In order to achieve high productivity, it is preferred to use a mold having a symmetric structure about the rotary shaft of the rotary mechanism.

[0021] According to the present invention, there is provided a method for manufacturing a wire structure for obtaining a wire structure wherein said wire is strained three-dimensionally at prescribed pitches between said groove portions and at pitches of the thickness of said spacer comprising steps of: using a wire feeding mechanism, a spacer provided with grooves for straining a wire by arranging it at prescribed pitches formed at prescribed pitches and at prescribed depths, a guide block provided with notched portions for defining the straining position of said wire and supporting the tensile strength of said wire formed at prescribed pitches, a mold for mounting said spacer and said guide block, and a rotary mechanism for rotating said mold; rotating said mold while adjusting the feeding position of said wire from said wire feeding mechanism so that said wire is received in said prescribed notched portions and said groove portions; and stacking said spacers and/or said

guide blocks to said mold while suspending the rotation of said mold instantaneously.

[0022] Preferably, the guide block is disposed in such a manner as to lessen the stress due to the tensile strength of the wire applied to the edge portion of the spacer to prevent the deformation of the spacer so that the accuracy of the position where the spacers are stacked is ensured.

[0023] According to the present invention, there is further provided a method for manufacturing a conductive material comprising steps of pouring a insulating material into a wire structure obtained either by the above described the first to the third methods of three-dimensional wire alignment or the method of manufacturing the wire structure, curing the insulating material, and slicing the cured insulating material along the planes traversing the wire.

[0024] Preferably, the insulating material is any one of rubber, plastic, or plastic-ceramics composites.

Brief Description of Drawings

[0025]

Fig. 1 is a schematic block diagram of the apparatus for implementing a method of three-dimensional wire alignment (first method of alignment) of one embodiment according to the present invention.

Fig. 2 is a side view of the apparatus shown in Fig. 1.

Fig. 3 is a perspective view illustrating one example of the border-like frame body.

Fig. 4 is a perspective view illustrating one example of the wire structure.

Fig. 5 is a schematic block diagram illustrating one embodiment of a method of three-dimensional wire alignment (second method of alignment) and an apparatus for three-dimensional wire alignment (first apparatus of alignment) for implementing the same according to the present invention.

Fig. 6 is an explanatory drawing illustrating an example of a separator plate.

Fig. 7 is an explanatory drawing illustrating another embodiment of an apparatus for three-dimensional wire alignment (second apparatus of alignment) according to the present invention.

Fig. 8 is a plan view of the wire feeding mechanism shown in Fig. 7 viewed from the top of Fig. 7.

Fig. 9 is an explanatory drawing illustrating a structure of a molding used for the wire apparatus of alignment shown in Fig. 7.

Figs. 10(a),(b),(c),(d) are explanatory drawings illustrating one embodiment of a guide block structure used for the apparatus for three-dimensional wire alignment shown in Fig. 7. Fig. 10(a) is a rear elevation, Fig. 10(b) is a plan view, Fig. 10(c) is a front view and an enlarged view of the notched portion, and Fig. 10(d) is a cross-sectional view.

Fig. 11 is a perspective view illustrating one embodiment of the spacer used for the apparatus for three-dimensional wire alignment shown in Fig. 7.

Fig. 12 is an explanatory drawing illustrating the state of the wire strained between multiple layers of spacers and a guide block in the apparatus for three-dimensional wire alignment shown in Fig. 7.

Fig. 13 is a cross-sectional view illustrating the state of spacer being stacked in the apparatus for three-dimensional wire alignment shown in Fig. 7.

Fig. 14 is a partially perspective view illustrating one example of the composite block body manufactured according to the method of manufacturing a conductive material of the present invention.

Fig. 15 is a perspective view illustrating one example of the printed circuit board material obtained by the method of manufacturing a conductive material according to the present invention.

Fig. 16 is a perspective view illustrating an example of the printed circuit board.

Best Mode for Carrying Out the Invention

[0026]

The method of three-dimensional Wire alignment according to the present invention may be classified in general into the following three methods: 1. A method of alignment comprising steps of disposing a border-like frame body (frame shaped spacer) peripherally of the rotary shaft, winding a wire on the border-like frame body by rotating the rotary shaft, repeating steps of stacking another set of border-like frame bodies onto the above described border-like frame bodies and winding a wire again thereon (first method of alignment); 2. A method of alignment comprising steps of disposing separator plates on the sides of the prism space, wiring a wire on the separator plates by rotating the prism space about the central axis, repeating steps of stacking another set of separator plates on the above described separator plates and winding a wire again thereon (second method of alignment); and 3. A method of alignment comprising steps of, in contrast to the above described first and second methods, building a mold by disposing a border-like frame body (frame shaped spacer) or separator plates, fixing the mold, winding a wire on the border-like frame body or separator plates by moving the wire bobbin around the mold, repeating steps of stacking another set of border-like frame bodies or separator plates on the above described border-like frame body or separator plates and winding a wire again thereon (third method of alignment).

[0027] The present invention will be now described in detail according to embodiments, however, it is to be understood that the invention is not limited to these specific embodiments thereof.

[0028] Fig. 1 is a schematic block diagram illustrating one embodiment of the apparatus for implementing the method of three-dimensional wire alignment accord-

ing to the present invention, and Fig. 2 is a side view of the apparatus shown in Fig. 1.

[0029] The apparatus for three-dimensional wire alignment 10 comprises a rotary shaft 11 and four border-like frame bodies (frame shaped spacers) disposed peripherally of the rotary shaft. The border-like frame body 12 has a shape as shown in Fig. 3 and has a thickness corresponding to the pitch of the wire 13 to be wound. On these four border-like frame bodies 12 disposed peripherally of the rotary shaft 11, the wire 13 fed from the wire bobbin 14 may be wound. When starting winding, the wire 13 is fixed at the fixing portion (not shown) provided in the vicinity of the apparatus for three-dimensional wire alignment 10. Reference numeral 15 represents a base for supporting the rotary shaft 11 and the border-like frame body 12 as well as four wire bobbins 14 via the arm 16.

[0030] The wire 13 fed from the wire bobbin 14 is wound on the border-like frame body 12 generally via a guide or the like which is not shown at prescribed pitches.

[0031] In the apparatus for three-dimensional wire alignment 10 having a construction shown above, the wire 13 may be wound on the border-like frame body 12 by rotating the rotary shaft 11 one turn by means of a motor, which is not shown, synchronized with the rotation of the wire bobbin 14. Then another set of border-like frame bodies 12 is stacked on these border-like frame bodies 12, and a wire 13 is wound on another set of border-like frame bodies 12. These steps are repeated.

[0032] In this embodiment, since the apparatus comprising four border-like frame bodies 12 disposed peripherally of the rotary shaft 11 so that the cross-section taken along the axis is square in shape, the rotation of the rotary shaft 11 is proceeded by 90° , and each time the rotary shaft 11 rotates by 90° , steps of stacking the border-like frame body 12 and winding of the wire 13 are carried out. As a matter of course, the number of the border-like frame body 12 peripherally of the rotary shaft 11 is not limited to four and could be only one. However, it is preferable to dispose four border-like frame bodies, because the cross-section taken along the axis will have the geometry of a square so that the wire structure may be manufactured through the efficient use of the periphery of the rotary shaft 11.

[0033] In this way, by repeating steps of stacking another set of border-like frame bodies 12 thereon after every rotation of the rotational shaft 11, and winding a wire 13 thereon at prescribed pitches, a wire structure having wire 13 aligned at prescribed pitches accurately and three-dimensionally may be obtained.

[0034] According to the steps described above, four wire structures as shown in Fig. 4 are obtained. After manufacturing four wire structures 17, the wire portions extending between each wire structure 17 are cut to remove each wire structure 17 from the periphery of the rotary shaft 11, and four border-like frame bodies 12 are

disposed again peripherally of the rotary shaft 11, and then the same steps as described above are repeated.

[0035] In the wire structure obtained in this way, since the wire is aligned accurately and three-dimensionally at prescribed pitches, a member that can conduct electricity only in one direction such as an anisotropic conductive material may be manufactured by embedding the wire structure into rubber or a resin and cutting into pieces of an appropriately size.

[0036] The second method of alignment and an apparatus therefore will now be described.

[0037] Fig. 5 is a schematic block diagram illustrating one embodiment of the method for three-dimensional wire alignment (second method of alignment) and the apparatus for three-dimensional wire alignment (first apparatus of alignment) for implementing the same.

[0038] In Fig. 5, reference numeral 20 represents an apparatus for three-dimensional wire alignment, and in this apparatus 20, a prism space 21 is defined by, with a prism space 21 in mind, two side plates 22 and 23 disposed in the direction perpendicular to the axis of the prism space facing with respect to each other and two separator plates 24, 25 of a prescribed thickness and disposed on one side of the prism space parallel with and spaced a prescribed distance from the axis of prism space 21.

[0039] The apparatus is constructed in such a manner that the side plates 22, 23 and the separator plates 24, 25 are rotated peripherally of the axis of the prism space 21 defined in such a manner by a driving means such as a motor, which is not shown here. On the side of the outer periphery of these two separator plates 24, 25, the wire 28 fed from the wire bobbin 26 through a guide 27 at prescribed pitches. Reference numeral 29 represents an axis of the prism space 21.

[0040] Fig. 6 shows a preferred example of the separator plates 24, 25, which are provided with V-shaped grooves 30 on its end surface at prescribed pitches. This arrangement is preferable because the wire may be aligned accurately.

[0041] In the apparatus for three-dimensional wire alignment 20 having such a structure, two separator plates 24, 25 each having a prescribed thickness are disposed on any one side surface of the prism space 21 keeping a prescribed distance apart, and the prism space 21 is rotated about the central axis many turns.

[0042] As described above, by rotating the prism space 21, that is, side plates 22, 23 and separator plates 24, 25 about the central axis many turns, a wire 28 is wound on two separator plates 24, 25 at prescribed pitches so that the wire 28 is aligned over the surfaces thereof. Then, steps of staking another two separator plates on these two separator plates 24, 25, and winding a wire thereon at prescribed pitches again are repeated prescribed times.

[0043] In this way, a wire structure 17 wherein the wire is wound at prescribed pitches accurately and three-dimensionally (See Fig. 4) is obtained.

[0044] After the steps of manufacturing the wire structure, cutting the wire outside the separator plates 24, 25 to remove the wire structure, and disposing two separator plates on any one side surface of the prism space 21 keeping a prescribed distance apart again, and then repeating steps as described above.

[0045] In the embodiment shown in Fig. 5, though one piece of the wire structure is manufactured, it is also possible to manufacture two pieces of wire structures on any two side surfaces of the prism space 21 perpendicular to the central axis 29 thereof and facing with respect to each other.

[0046] Though the third method of alignment is not described in detail, the wire structure 17 having the wire aligned at prescribed pitches accurately and three-dimensionally as shown in Fig. 4 is obtained also by the method wherein the mold is fixed and the wire bobbin is moved, which is reversal of the first and second methods of alignment comprising steps of, for example, in Fig. 5, building a mold by side surface plates 22, 23 and the separator plates 24, 25 which define the prism space 21 and moving a wire bobbin 26 and a guide 27 around the mold.

[0047] An embodiment of an apparatus for three-dimensional wire alignment (second apparatus of alignment) will now be described.

[0048] Fig. 7 is an explanatory drawing illustrating one embodiment of the apparatus for three-dimensional wire alignment (second apparatus of alignment. Hereinafter referred to as "apparatus of alignment"). The apparatus of alignment 1 comprises a main body 1A for manufacturing a wire structure, and a wire feeding mechanism 1B for feeding the wire 2 to the main body 1A. Of course, it may be formed as an integrated apparatus. Fig. 7 is accompanied by an enlarged cross sectional view of mainly the guide block 5 to be stacked in the main body 1A.

[0049] The plan view of the wire feeding mechanism 1B of Fig. 7 viewed from the top of Fig. 7 is shown in Fig. 8. The wire feeding mechanism 1B comprises a wire bobbin 3 on which a wire is wound, a torque motor 31 for applying a tensile strength to the wire 2, and a pulley 33 for feeding the wire from the prescribed position to the main body 1A, and all these elements are disposed on the same base 41. The base 41 has, as shown in Fig. 7, two stages in the vertical direction, and the wire 2 wound on the bobbin 3 disposed on the lower base 41 is fed through the hole portion 51 (Fig. 8) formed on the upper base 41 via a pulley disposed in a row on the upper base 41 at the prescribed location to the main body 1A.

[0050] As shown in Fig. 7 and 8, the base 41 comprising 2 stages is disposed on the sliding mechanism 71 provided on the upper surface of the supporting base 61, and the sliding mechanism 71 allows the base 41 to slide at prescribed pitches in the direction perpendicular to the paper of Fig. 7, and in the direction parallel to the paper of Fig. 8, which is shown by the arrow M. The pul-

leys 33 disposed in a row are fixed at prescribed positions, and preferably the distance between each pulley 33 is set at an integral multiple of the pitch of the grooves 37 formed on the spacer 4, which will be described later, according to the disposing pitch of the wire of the wire structure to be manufactured.

[0051] On the other hand, the main body 1A comprises a spacer 4 and a guide block 5 for straining the wire 2, a mold 6 for mounting the guide block 5, and a rotary mechanism 7 for rotating the mold 6. Fig. 9 shows an explanatory drawing of the structure of the mold 6 used in the apparatus of alignment 1 shown in Fig. 7 in detail.

[0052] Fig. 6 has a H-shaped cross section, and includes a mounting hole 42 for inserting the rotary shaft 8 of the rotary mechanism 7 in the center thereof. The mold 6 also includes side walls 62 each formed with positioning groove 52 for stacking the spacer 4 at prescribed positions, and comprises two recess portions 82A and 82B defined by the side walls 62 and the bottom surface portion 72 having a mounting hole 2 formed thereon. The guide block 5 is secured to the side walls 62 and/or the bottom surface portion 72 on the outside thereof by means of screws or the like.

[0053] The mold 6 has, assuming that the mounting hole 42 is a central axis thereof, configuration symmetry about the central axis, and the wire structure is formed in each recess portion 82A and 82B. Such recess portions formed on the mold used for the apparatus of alignment of the present invention is not limited to be formed at two positions, but it may be formed at one position or three positions. When the mold having a plurality of recess portions is used, the length of the wire extending from one wire structure to another structure may be reduced so that the waste of wire is reduced.

[0054] By using the rotary mechanism 7, when the mold 6 is rotated in a prescribed direction, for example, clockwise as shown in Fig. 7, the wire 2 is strained at a constant tensile strength through the guide block 5 disposed on the upper right side first, then the spacer 4 on the upper right side, and the spacer 4 on the upper left side, then the guide block 5 on the upper left side of the main body 1A. The lower recess portion 82B of the mold 6 is then moves to the upper side thereof, the wire 2 is tightened in the recess portion 82B as in the recess portion 82A. In this way, by performing the installation of spacer 4 and the guide block 5 while suspending the revolution instantaneously during revolution of the mold 6 by approximately a prescribed angle, a wire structure having a wire 2 strained at prescribed intervals may be obtained.

[0055] The detail structure and the method of straining the wire 2 will be now described.

[0056] First, the guide block 5 and the spacer 4 are mounted on the mold 6 for the first stage (the lowest stage) in advance. The tip of the wire 2 drawn from the wire feeding mechanism 1B is fixed at a prescribed position by the use of side surface of the bottom surface

portion 72 of the mold 6 or the like, for example, at the fixing point 92 shown in Fig. 9 by the use of a screw or other various means.

[0057] The mold 6 is rotated by approximately a prescribed angle to strain the wire 2 to a guide block 5 disposed on the side of the fixed point 92 on one of the recess portion 82A so that the wire 2 is received in the notched portion 35 formed on the guide block 5. In the case where the wire feeding mechanism 1B shown in Fig. 7 and Fig. 8, eight parallel portions of wire 2 are strained at prescribed distances simultaneously.

[0058] An explanatory drawings illustrating one embodiment of the guide block 5 are shown in Fig. 10(a), (b), (c), and (d). Fig. 10(a) is a rear elevation, Fig. 10(b) is a plan view, Fig. 10(c) is a front view and an enlarged view of a notched portion 22, and Fig. 10(d) is a cross-sectional view, and the guide block 5 is formed with notches 35 on the edge of one side thereof at prescribed pitches. The wire is hooked on the notch 35, and by further rotating the mold 6, it is guided to the groove portion 37 of the spacer 4 so that the wire 2 is received between the notched portion 35 and the groove portion 37.

[0059] Fig. 11 is a perspective view illustrating one embodiment of the structure of the spacer 4. On the upper surface of the spacer 4, the groove portion 37 is formed at the same disposing pitches as that of the notched portion 35 on the guide block 5 along the direction in which the wire is strained. By straining the wire so as to be received in the groove portion 37, the intervals between the portions of wire 2 strained on the upper surface of the spacer 4 become constant so that the accuracy of the straining position of the wire 2 is ensured.

[0060] As described later, since the spacer 4 is stacked one by one, defining the depth of the groove portion 37 larger than the diameter of the wire 2 allows the upper and lower surfaces of the spacers 4 to be in direct contact with each other when stacked, as shown in Fig. 13. In this way, the disposing pitch of the wire 2 in the direction of stacking of the spacer 4 is also kept correctly so that the straining accuracy of the wire is improved.

[0061] In order to maintain the straining accuracy of the wire 2, accurate formation of the groove portion 37 is required. As a method of forming the groove portion 37, preferably, a chemical method such as chemical etching or the like, or a mechanical process such as dicing is used.

[0062] The wire 2 received in the groove portion 37 so as to be received in parallel in this manner is received in the groove portion 37 formed on another spacer 4 disposed in the recess portion 82A, which allows the wire to be strained between the spacers 4. In addition, the wire 2 is guided to the notched portion 35 formed on another guide block 5 disposed in the recess portion 82A, and strained between another spacer and another guide block 5. The first wiring operation

between the guide blocks 5 in the recess portion 82A is completed in this way. Then, the mold 6 is rotated, the wire 2 is strained between the guide blocks 5 to complete the first wiring operation in the recess portions 82A and 82B.

[0063] As described above, it is preferable that the intervals between each pulley, in other words, the intervals between wires 2 to be fed is an integral multiple of the disposing pitch of the groove portion 37 formed on the spacer 4 (the same disposing pitch as that of the notches 35 formed on the guide block 5) in the wire feeding mechanism 1B. Therefore, when the disposing pitch of the groove portion 37 and the spacing between pulleys are the same, the wire structure may be obtained by rotating the mold 6 while disposing the spacer 4 and the guide block 5 adequately without the sliding mechanism 71 of the wire feeding mechanism 1B.

[0064] On the other hand, when the spacing between the pulleys 33 is equal to or more than two times the disposing pitch of the groove portion 37, the wire feeding position is adjusted by sliding the base 41 by a disposing pitch of the groove portion 37 after the wire is strained in the recess portion 82B before the wire 2 is strained in the recess portion 82A again by the use of sliding mechanism 71 in the wire supplying mechanism 1B so that the wire is guided to the notched portion 35 and the groove portion 37 adjacent to the notched portion and the groove portion where the wire is already strained.

[0065] After adjustment of the wire feeding position is performed, another eight parallel wires 2 which are parallel to eight wires 2 previously strained by rotating the mold 6 one turn are strained. Steps of adjusting the wire feeding position by the sliding mechanism 71 and rotating the mold 6 are repeated until all the groove portions 37 formed on one spacer 4 are applied with wires 4. It is needless to say that, when such a sliding mechanism 71 is used, setting the first feeding position of the wire 2 so that all the groove portions 37 formed on one spacer 4 are applied with the wires 2 is required.

[0066] After all the grooves 37 of the spacer 4 on the first stage are applied with the wire 2, the second stage of the spacer 4 is disposed. By moving the sliding mechanism 71 in the opposite direction in which the wire is applied on the space of the first stage, the wire application on the spacer 4 on the second stage is performed. In this way, steps of disposing the spacer 4, adjusting the wire feeding position by the sliding mechanism 71, and rotating the mold 6 are repeated until a prescribed number of stages may be obtained.

[0067] The guide blocks 5 are required to be stacked corresponding to the stacking of the spacers 4. Here, only one guide block 5 may be used for multiple stages of guide blocks 4. In other words, as shown in an explanatory drawing of Fig. 12, in the spacers 4 stacked to a prescribed number of stages, it is possible to strain the wire 2 between a plurality of groove portions 37

positioned on an imaginary lines extending almost straightly parallel to the direction of stacking and a notched portion 35 formed on one guide block 5. In this way, by reducing the number the guide block 5 to be used, the cost for components may be reduced and the manufacturing operation of the wire structure may be simplified.

[0068] Of course, the notch 35 must have sufficient depth and width to receive all the wires 2, since a plurality of wires 2 are to be received therein. Previously described enlarged view of the notched portion 35 of Fig. 10(c) illustrates the state where twenty-four pieces of wires 2 are received in the notched portion 35. In other words, one guide block (single stage) 5 is used for the spacers 4 stacked into twenty-four stages.

[0069] In this way, when a single stage of guide block is used for multiple stages of spacers 4, as shown in Fig. 7 and Fig. 12, the wires 2 present the state of spreading out at a constant angles toward the stacking direction of the spacers 4. Since another guide block is disposed on this single guide block 5, if such another guide block 5 comes into contact with previously strained wire 2 or bent the wire 2, the tensile force of the wire 2 may vary, or the wire 2 may be damaged and broken.

[0070] Therefore, according to the present invention, it is preferred to form a bevel portion on the guide block 5 corresponding to the straining angle of the wire 2 so that the wire strained to the spacer 4 does not come in contact with the portion of guide block 5 other than the notched portion 35 of the guide block 5. As shown in an enlarged view of Fig. 7 and a cross-sectional view of Fig. 10(d), the bevel portion 53 is formed on the lower surface of the guide block 5.

[0071] In the case of the apparatus of alignment 1 shown in Fig. 7, the wire 2 is applied to be bent at the notched portion 35 at an angle of about 90 degrees. In this case, if the contour of the bottom portion of the notched portion has a sharp edge, the wire 2 tends to be bent and broken at that edge portion. Therefore, as shown in Fig. 10(d), it is preferable that the bottom portion of the notched portion 35 is formed in a profile having a plurality of obtuse angles combined or a curvature so that the wire 2 is not bent excessively.

[0072] When stacking the guide blocks 5 corresponding to the stacking of the spacers 4, if the notched portion 35 is positioned on the imaginary line parallel to the stacking direction of the guide blocks 5 (the same direction as the stacking direction of the spacers 4), the wires 2 applied in the recess portion 82A and 82B are overlapped one another on the side surface of already disposed guide block 5.

[0073] In such a case, since the wires 2 have a tendency not to run straight, there may occur problems such that the tensile force of the wire 2 may slightly vary, or that the wire may form a kink due to contact between wires 2 which may lead to breakage thereof. In addition, it may cause another problem such that after manufac-

turing of the wire structure is complete, it may require much time and expense in cutting the wire 2 when taking out the wire structure out of the mold 6.

[0074] In order to solve the problems described above, as shown in an enlarged view of Fig. 7, it is preferable to define the configuration and/or the stacking position of the guide block 5 in such a manner that the distance between the spacer 4 and the notched portion 35 formed on the guide block 5 is getting longer as the number of stacked guide blocks 5 increases.

[0075] This ensures that the wire 2 is received in the notched portion 35 and the wires 2 are disposed approximately in parallel without overlapping one another between the recess portion 82A and 82B, so that the straining accuracy of the wire 2 is ensured and cutting operation of the wire 2 after the wire structure is manufactured may be facilitated.

[0076] Preferably the structure of the guide block 5 is such that it is screwed to the side wall 62 or the like of the previously mounted guide block 5 and/or the mold 6 by the use of screw hole 55 or the like shown in Fig. 10 (a) to (d) as it is stacked one after another so that the position thereof is fixed.

[0077] By using the guide block 5 described above, the wire 2 is prevented from being bent extremely at the edge portion of the spacer 4, and thus the pressure applied by the wire 2 is distributed without being concentrated onto the edge portion so that the spacer 4 may be kept free from deformation. This enables the stacking of multiple layers and the straining accuracy of the wire 2 between the spacers 4 is preferably maintained.

[0078] As described above, when steps of rotating the mold 6, operating the sliding mechanism 71, and stacking a prescribed number of the spacer 4 and the guide block 5 are performed in a prescribed order and the straining of the wire 2 is finished, the wire is cut off with the tensile strength kept constant. Maintaining the tensile strength of the wire 2 may be achieved by forming a fixing point that is the same as the fixing point 92 formed on the mold 6 on the guide block 5 disposed on the uppermost stage.

[0079] As a next step, as described above, after the wire structure is obtained by the use of the first to the third methods of three dimensional wire alignment or the first or the second apparatus of alignment, an insulating material such as rubber, plastic or plastic-ceramic composites is poured into the wire structure and cured.

[0080] Pouring of an insulating material into the wire structure is generally carried out by placing the wire structure into the mold and introducing the insulating material into the mold in melted state. Preferably, pouring operation is carried out by vacuum casting method.

[0081] Then, when the insulating material is cured, by removing the border-like frame body, the separator plate and the guide block and so on, a composite block body 38 having wires 34 disposed at prescribed pitches may be obtained.

[0082] In Fig. 14, the composite block body 38 comprises an insulating material such as rubber, plastic, or a plastic-ceramic composites 32 having conductive wires 34 disposed at prescribed pitches.

[0083] The wires 34 is disposed in such a manner that they extend linearly from a surface 36 of the composite block body 38 to another surface 39 opposed to the surface 36, and project from the surface 36 and from another surface 39.

[0084] When such a composite block body 38 is obtained, the composite block body 38 is sliced (cut) along the surfaces A1, A2, that are perpendicular to the wire 34 by means of a band saw, wire saw, or the like so that a conductive material such as a printed circuit board material or an anisotropic material may be obtained.

[0085] According to the method described above, since the wire 34 may be arranged at prescribed intervals accurately in dimension, a printed circuit board material with the wires 34 arranged at narrower pitches (high density), for example, at pitches of 1.27mm or below may be obtained, and what is more, crosstalk which is likely to be happen with narrow pitches may be minimized.

[0086] Fig. 15 illustrates an example of a printed circuit board material manufactured by the manufacturing method according to the present invention. In Fig. 15, the board material 40 is composed of plastic and ceramic, and comprises an insulating material 43 formed in the shape of a plate and wires 44 disposed at prescribed pitches. The ends of wires 44 are projecting from both sides of the insulating material 43 so that both sides of the board material 40 are electrically conducted.

[0087] The board material 40 having such a structure may be formed into a printed circuit board, for example as shown in Fig. 16, with a conductive layer (photo process layer) 45 having a prescribed circuit thereon, and a group of connection terminals 46 disposed on both sides.

[0088] The material used for conductive material will now be described.

[0089] In the present invention, a printed circuit board material or an anisotropic conductive material may be used as a conductive material. The constituting material may be any material such as rubber, plastic, glass, ceramic, etc., as far as it is an insulating material.

[0090] In the case where the conductive material is a printed circuit board material, an insulating material constituting the board material is preferably composed of plastic and ceramic, and is constructed in such a manner that ceramic particles, ceramic fibers or the like is dispersed into the matrix of plastic.

[0091] While the compounding quantity of both components may be selected adequately according to the characteristics such as insulating property, low heat expansibility, abrasion resistance, and so on or the objectives thereof, it is preferable to contain from 40 vol-

ume % to 90 volume % of ceramic particles, ceramic fibers or the like considering that low heat expansibility and volumetric shrinkage due to hardening is small within this range.

[0092] In the insulating material of the present invention, since the volumetric shrinkage due to hardening may be 1% or less, or further 0.5% or less, it is quite advantageous for improvement of the dimensional accuracy of the wire in the board material.

[0093] By adjusting the compounding quantity in the range described above, low heat expansibility and abrasion resistance may be added effectively to the insulating material. If the content of ceramic particles or ceramic fibers exceeds 90 volume %, the content of plastic is insufficient which may result in loss of flow property during molding operation.

[0094] Ceramic includes glass such as quartz glass as well as alumina, zirconia, and nitriding silicon. Ceramic is mixed in the state of particles or fibers.

[0095] As plastic, any of thermoplastic resin and thermosetting resin may be used. Thermoplastic resin includes various resins such as vinyl chloride, polyethylene, polypropylene, polycarbonate, liquid quartz polymer, polyamide, polyimide or combination of two or more thereof.

[0096] On the other hand, as thermosetting resin, phenol resin, epoxy resin, urea resin, or combination of two or more thereof may be used.

[0097] Preferably, the insulating material used for the board material described above is formed by mixing ceramic such as glass chips obtained by cutting glass fibers into a prescribed length or glass beads into plastic such as epoxy resin or the like, since it has no anisotropy in thermal expansion and superior in insulating property, low heat expansibility, abrasion resistance, and strength.

[0098] As a material used for the wire to be disposed in the insulating material at prescribed pitches, any kind of metal having conductivity may be used. However, it is preferable to be any one of copper, copper alloy, aluminum, or aluminum alloy. In addition, considering abrasion resistance, flexibility, oxidation resistance, and strength, the wire is preferably made of beryllium copper.

Industrial Applicability

[0099] According to the method of three-dimensional wire alignment and the apparatus therefor, a wire structure having wires aligned three-dimensionally and accurately at prescribed pitches may be obtained. Since disposition of a guide block reduce the pressure applied to the spacer, deformation of the spacer may be prevented and multi-layer stacking and upsizing of the spacer may be performed easily. Since positioning of the spacer in the mold is facilitated and the spacer is provided with a groove portion for receiving the wire, the accuracy of the wire positioning may be easily ensured.

In addition, control of the wire feeding position by means of sliding mechanism, employment of a guide block, and control of the position of guide block enable a speedup of manufacturing wire structures while maintaining a tensile strength of the wire constant. As a result, a large sized wire structure with high dimensional accuracy may be manufactured with improved productivity. By using this wire structure, a printed circuit board material or an anisotropic conductive material may be manufactured.

Claims

1. A method of three-dimensional wire alignment for manufacturing a wire structure including the wires aligned three-dimensionally at prescribed pitches comprising steps of:

providing one or more border-like frame body having a prescribed thickness peripherally of the rotary shaft;
winding a wire on said border-like frame body at prescribed pitches in such a manner that the wire surrounds said rotary shaft and said border-like frame body by rotating said rotary shaft; and
repeating steps of stacking another set of border-like frame bodies on said border-like frame bodies and winding a wire thereon at prescribed pitches.

2. A method of three-dimensional wire alignment for manufacturing a wire structure including the wires aligned three-dimensionally at prescribed pitches comprising steps of:

disposing two separator plates each having a prescribed thickness on any one or two side surfaces of the prism space keeping a prescribed distance with respect to each other;
winding a wire on said two separator plates at prescribed pitch by rotating said prism space about the central axis thereof many turns; and
repeating steps of stacking another set of separator plates on said two separator plates and winding a wire thereon at prescribed pitches.

3. A method of three-dimensional wire alignment for manufacturing a wire structure including the wires aligned three-dimensionally at prescribed pitches comprising steps of:

building a mold by providing one or more border-like frame body having a prescribed thickness around or by disposing two separator plates having a prescribed thickness on one or two side surfaces of circumference thereof keeping a prescribed distance with respect to

each other;

winding a wire on said border-like frame body or said separator plates for building said mold at prescribed pitches by moving the wire bobbin around said mold; and
repeating steps of stacking another set of border-like frame bodies or separator plates on said border-like frame bodies or separator plates, and winding a wire thereon at prescribed pitches.

4. The method of three-dimensional wire alignment as set forth in claim 2 or claim 3, characterized in that V-shaped grooves are formed at prescribed pitches on end surfaces of said separator plates.

5. An apparatus for three-dimensional wire alignment comprising;

two side plates disposed along the direction perpendicular to the axis of the prism space facing with respect to each other;
two separator plates each having a prescribed thickness and disposed in parallel keeping a prescribed distance with respect to each other for disposing on one or two side surfaces oriented in the direction of the axis of said prism space;
driving means for rotating said side plates and separator plates about the axis of the prism space defined by said side plates and said two separator plates; and
a wire bobbin for feeding a wire to be wound from the outside of said two separator plates at prescribed pitches.

6. The apparatus for three-dimensional wire alignment as set forth in claim 5, characterized in that V-shaped grooves are formed on end surfaces of the separator plates at prescribed pitches.

7. An apparatus for three-dimensional wire alignment comprising a wire feeding mechanism, a spacer and a guide block for straining a wire, and a mold for mounting said spacer and said guide block, and a rotary mechanism for rotating said mold, characterized in that groove portions for arranging said wire on said spacer at prescribed pitches are formed at prescribed pitches and at prescribed depths, and notched portions for defining the straining position of said wire and supporting the tensile strength of said wire are formed on said guide block at prescribed pitches.

8. The apparatus for three-dimensional wire alignment as set forth in claim 7, characterized in that the more said spacers and said guide blocks are stacked, the longer the distance between said

spacer and the notched portion formed on said guide block becomes.

9. The apparatus for three-dimensional wire alignment as set forth in claim 7 or claim 8, characterized in that the wire is strained between a plurality of groove portions located on an imaginary line almost straightly extending parallel to the stacking direction of the spacers and notches formed on a guide block when the spacers are stacked in prescribed multiple layers. 5
10. The apparatus for three-dimensional wire alignment as set forth in any of claims 7 to 9, characterized in that said guide block is provided with a bevel portion corresponding to the straining angle of said wire for preventing contact between the wire strained from said guide block to the spacer and the portion of said guide block other than the notch. 10
11. The apparatus for three-dimensional wire alignment as set forth in any of claims 7 to 10, characterized in that the bottom portion of the notch formed on said guide block is formed to have a profile having an obtuse angle or a curvature. 15
12. The apparatus for three-dimensional wire alignment as set forth in any of claims 7 to 10, characterized in that said wire feeding mechanism controls the wire feeding position by sliding itself in the direction parallel to the rotary shaft of the rotary mechanism in said mold. 20
13. The apparatus for three-dimensional wire alignment as set forth in any of claims 7 to 12, characterized in that said mold has a symmetric structure about the rotary shaft of said rotary mechanism. 25
14. A method for manufacturing a wire structure for obtaining a wire structure wherein said wire is strained three-dimensionally at prescribed pitches between said groove portions and at pitches of the thickness of said spacer comprising steps of: 30
 - using a wire feeding mechanism, a spacer provided with grooves for straining a wire by arranging it at prescribed pitches formed at prescribed pitches and at prescribed depths, a guide block provided with notched portions for defining the straining position of said wire and supporting the tensile strength of said wire formed at prescribed pitches, a mold for mounting said spacer and said guide block, and a rotary mechanism for rotating said mold; 35
 - rotating said mold while adjusting the feeding position of said wire from said wire feeding mechanism so that said wire is received in said prescribed notched portions and said groove 40

portions; and

stacking said spacers and/or said guide blocks to said mold while suspending the rotation of said mold instantaneously.

15. The method of manufacturing a wire structure as set forth in claim 14, characterized in that disposition of said guide block reduce the stress caused by the tensile strength of said wire applied to the edge portion of said spacer, and prevent said spacer from being deformed so that the accuracy of the position to be stacked may be ensured.
16. A method for manufacturing a conductive material comprising steps of:
 - pouring an insulating material into the wire structure obtained according to any one of methods as set forth in claims 1 to 3 and claim 14;
 - curing said insulating material; and
 - slicing said cured insulating material transversely of the wire.
17. The method for manufacturing a conductive material as set forth in claim 16, characterized in that said insulating material is any one of rubber, plastic, or plastic-ceramic composites. 45

FIG. 1

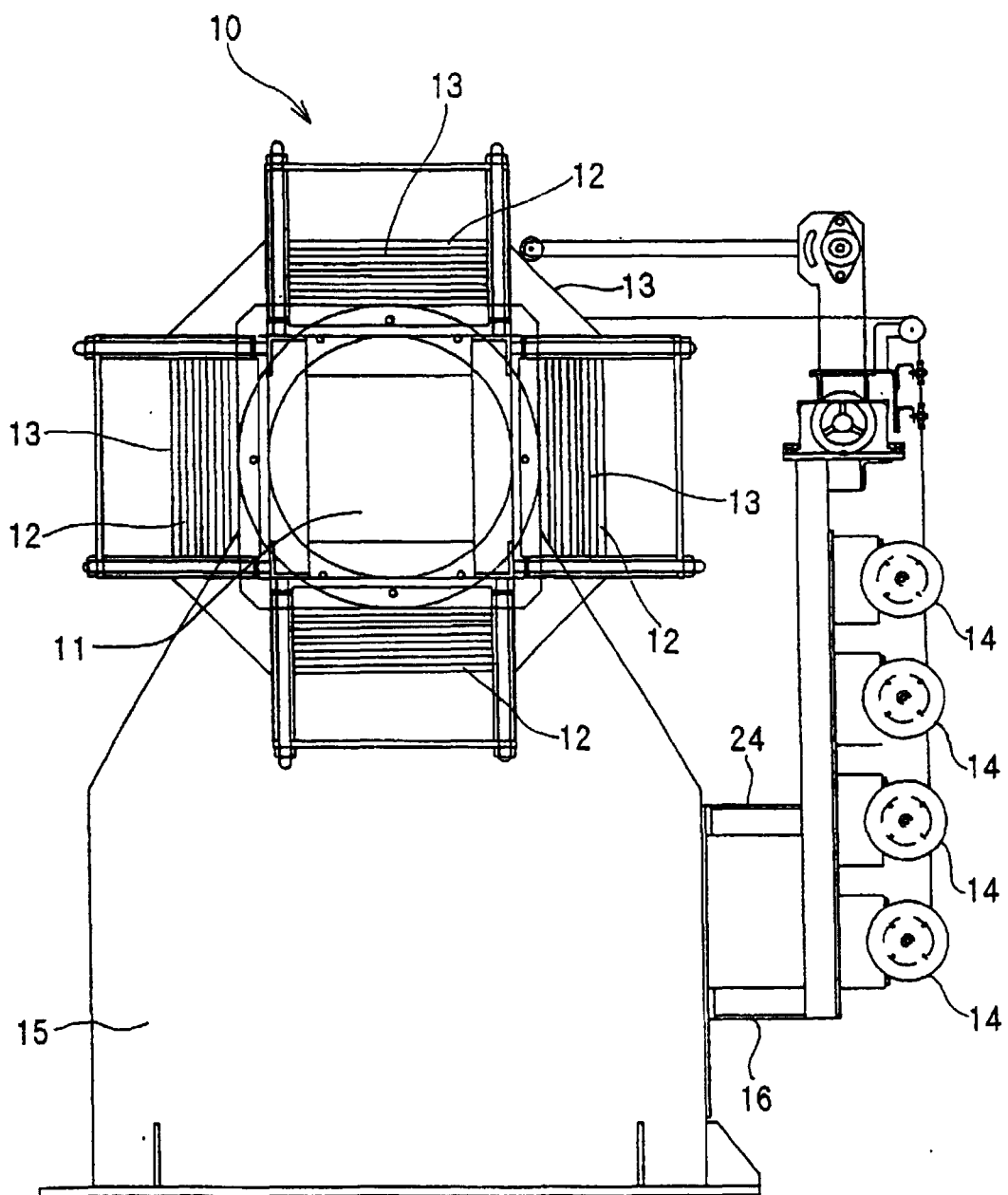


FIG. 2

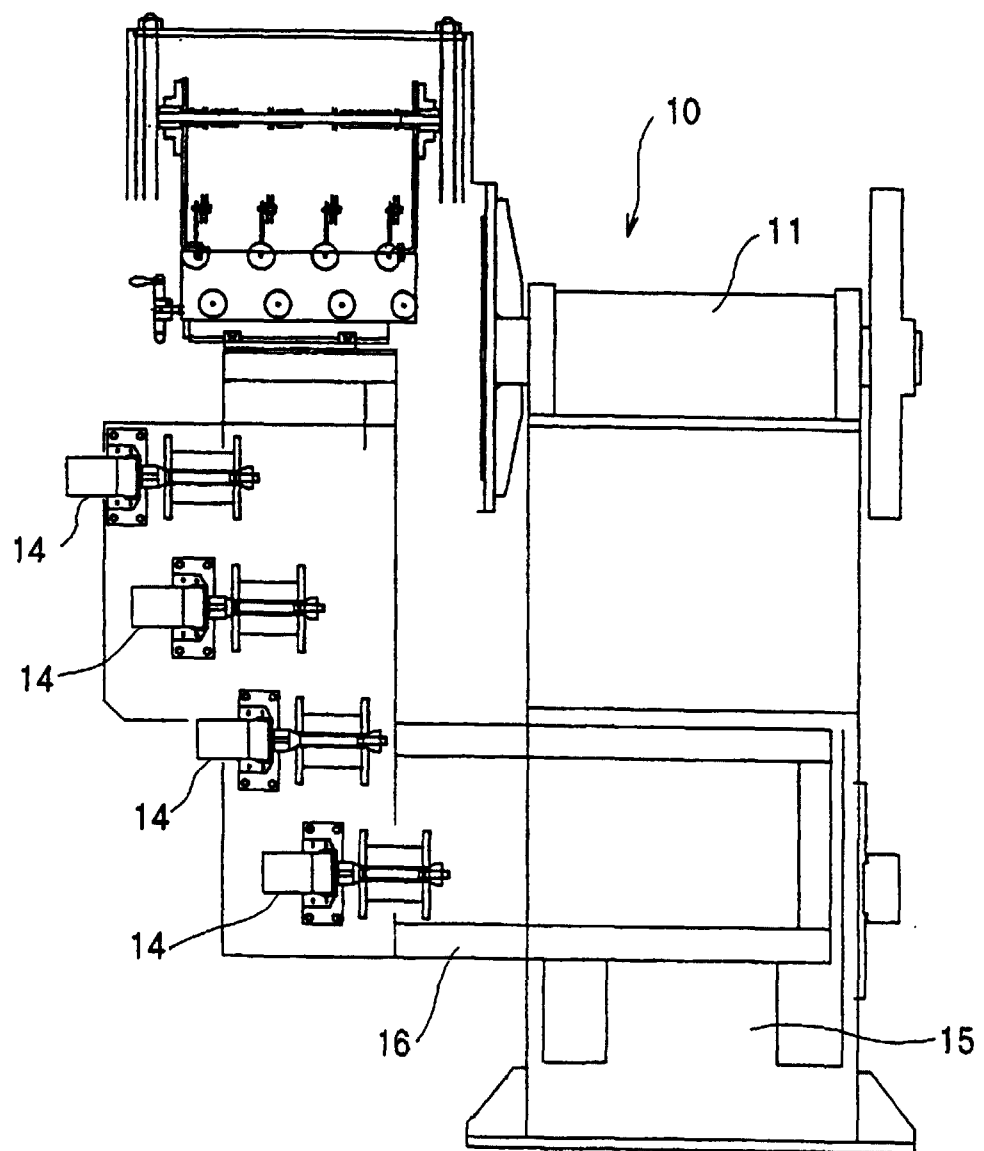


FIG. 3

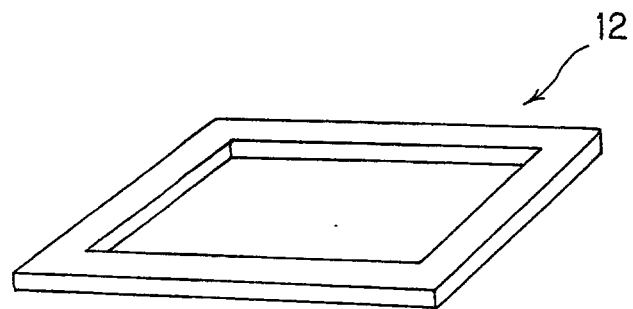


FIG. 4

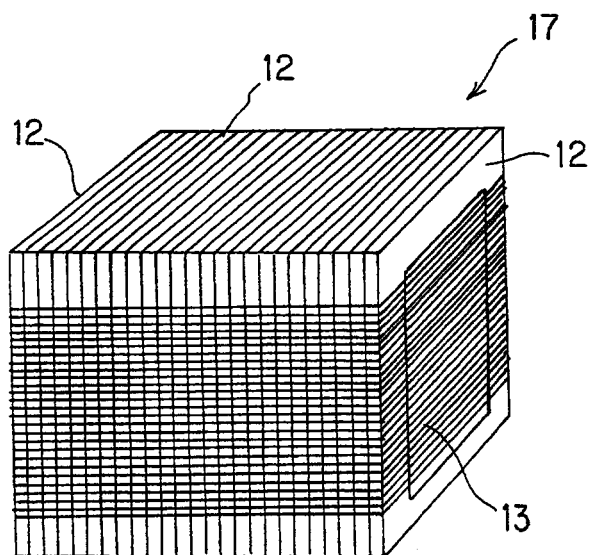


FIG. 5

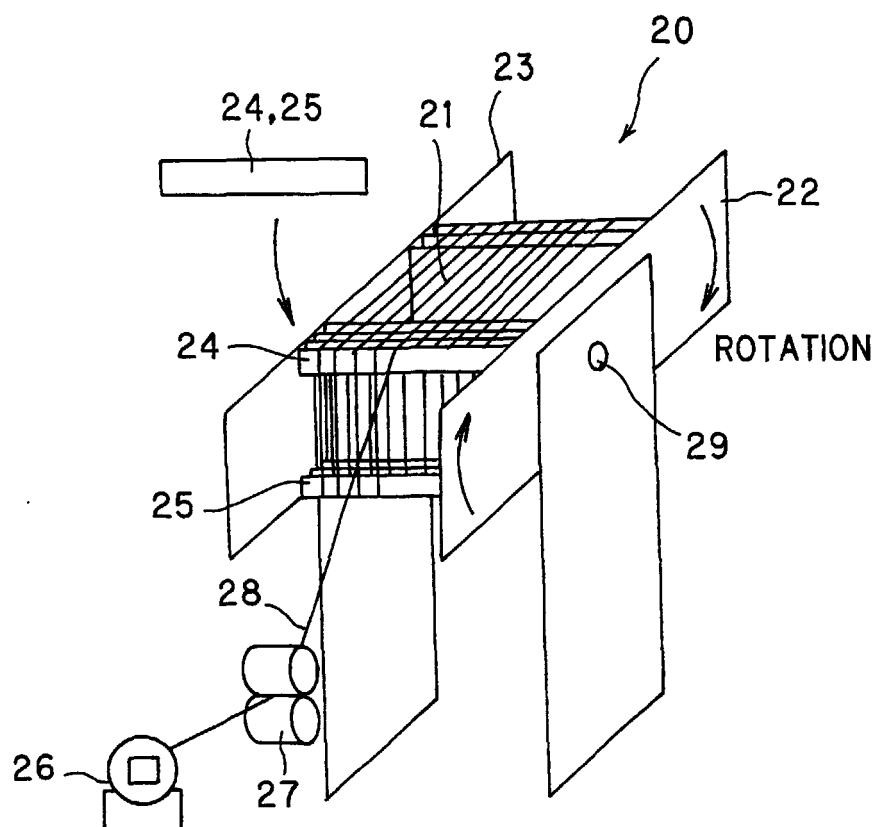


FIG. 6

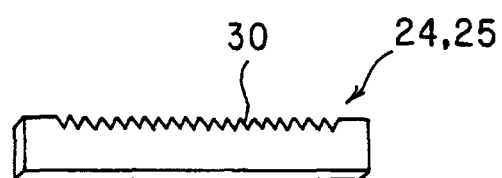


FIG. 7

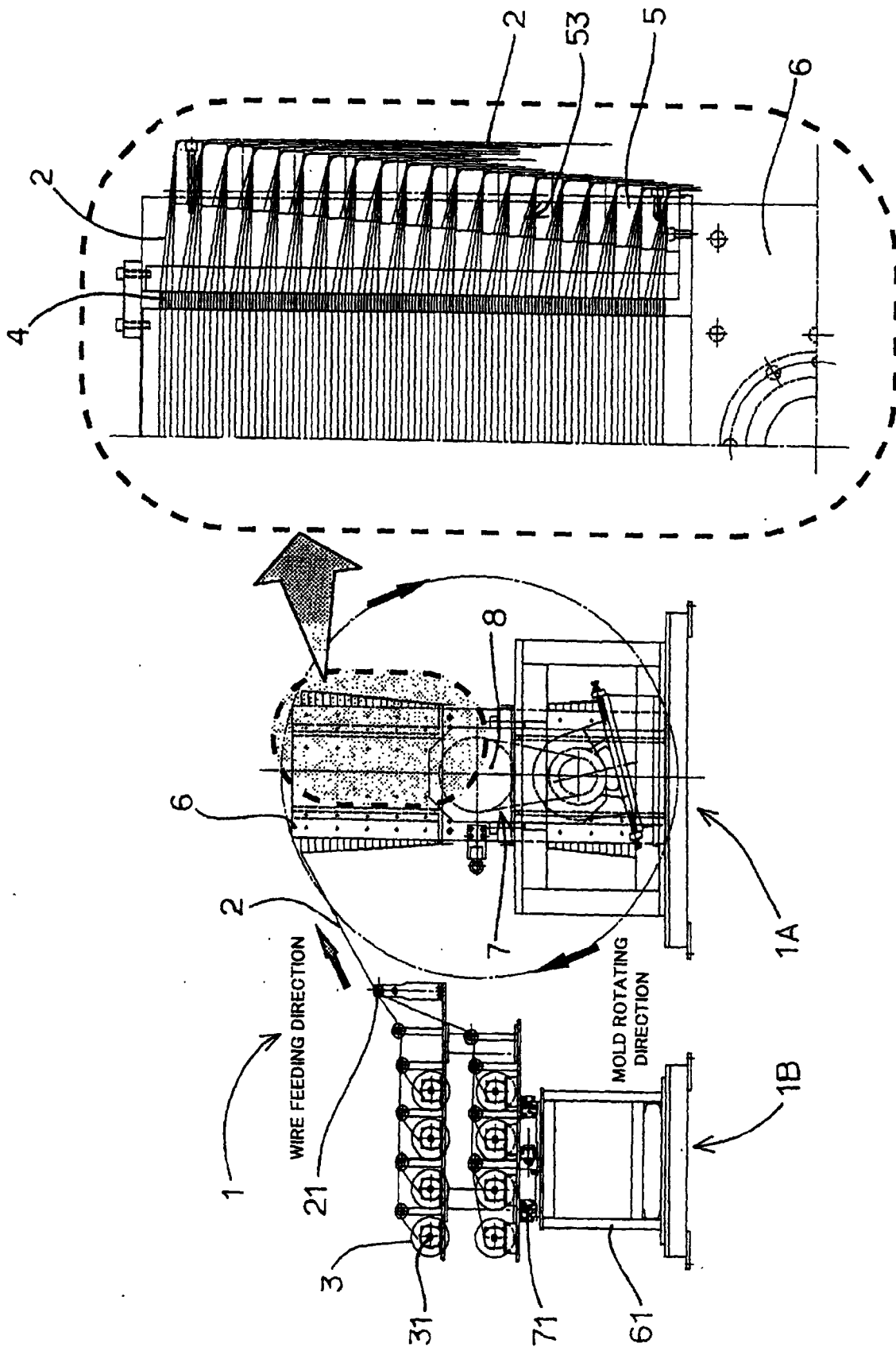


FIG.8

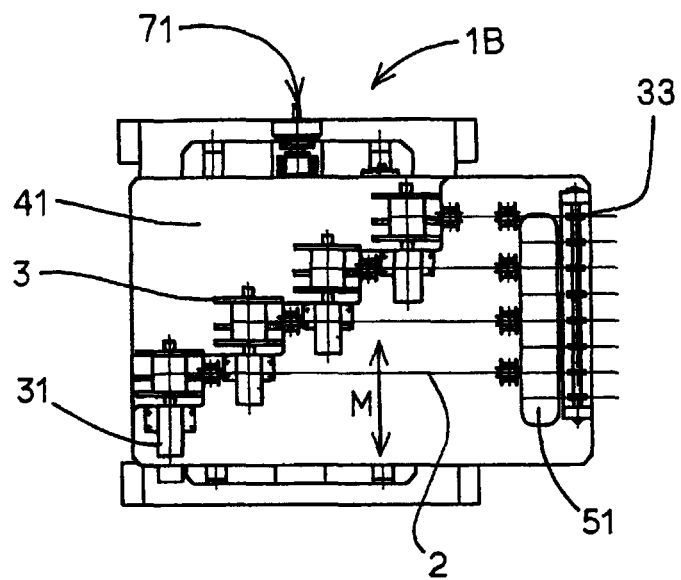


FIG. 9

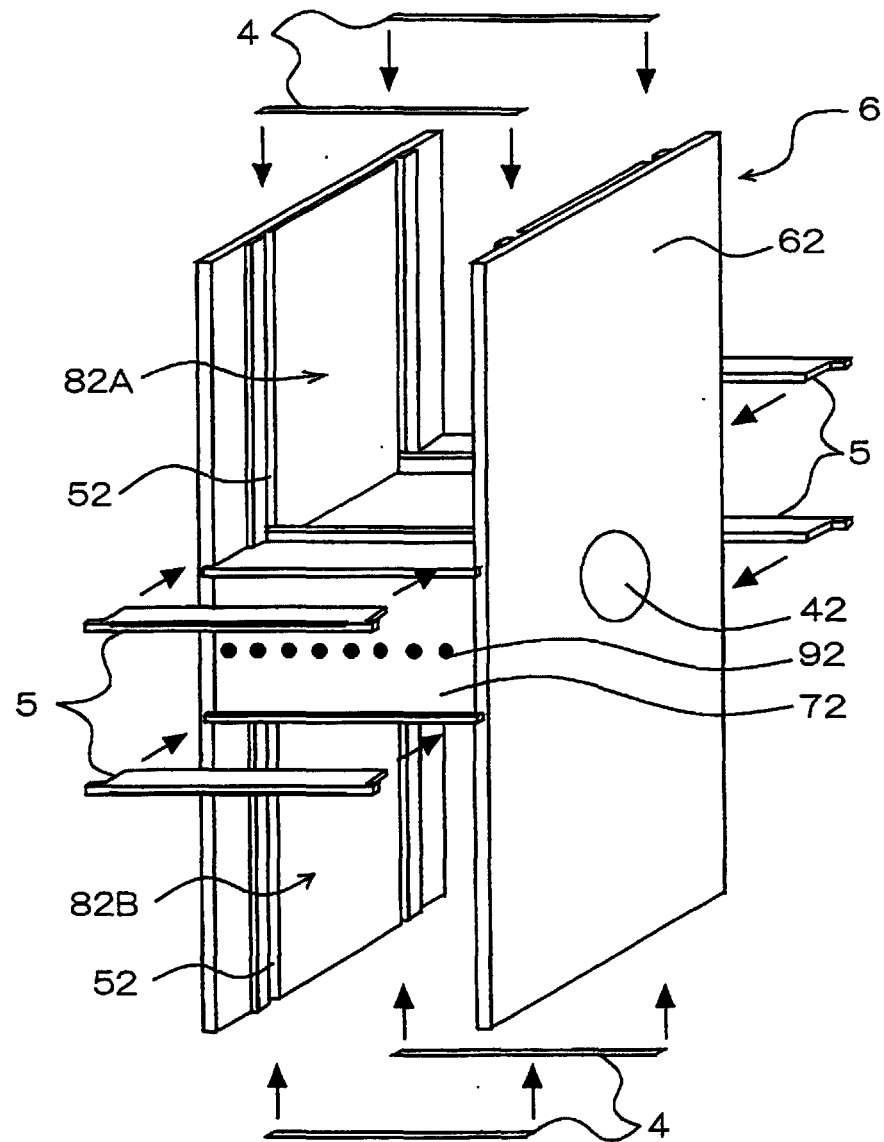


FIG.10(a)

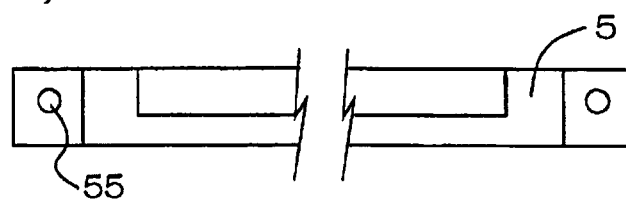


FIG.10(b)

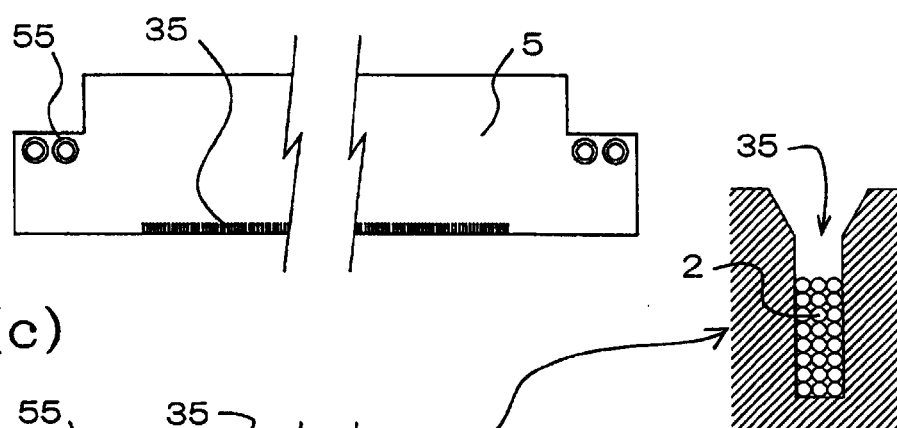


FIG.10(c)



FIG.10(d)

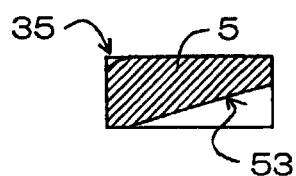


FIG.11

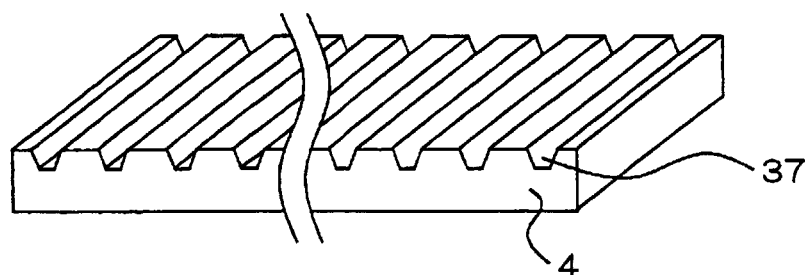


FIG.12

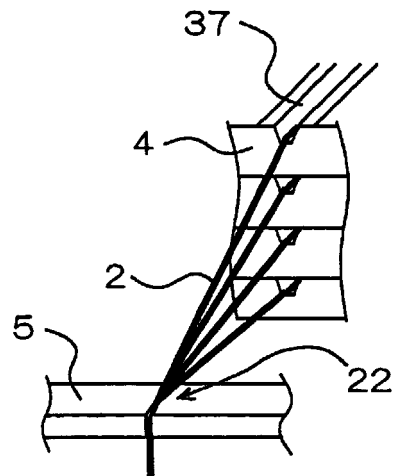


FIG.13

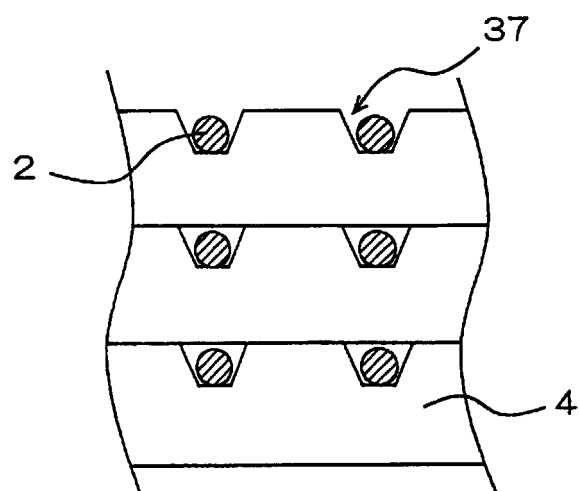


FIG. 14

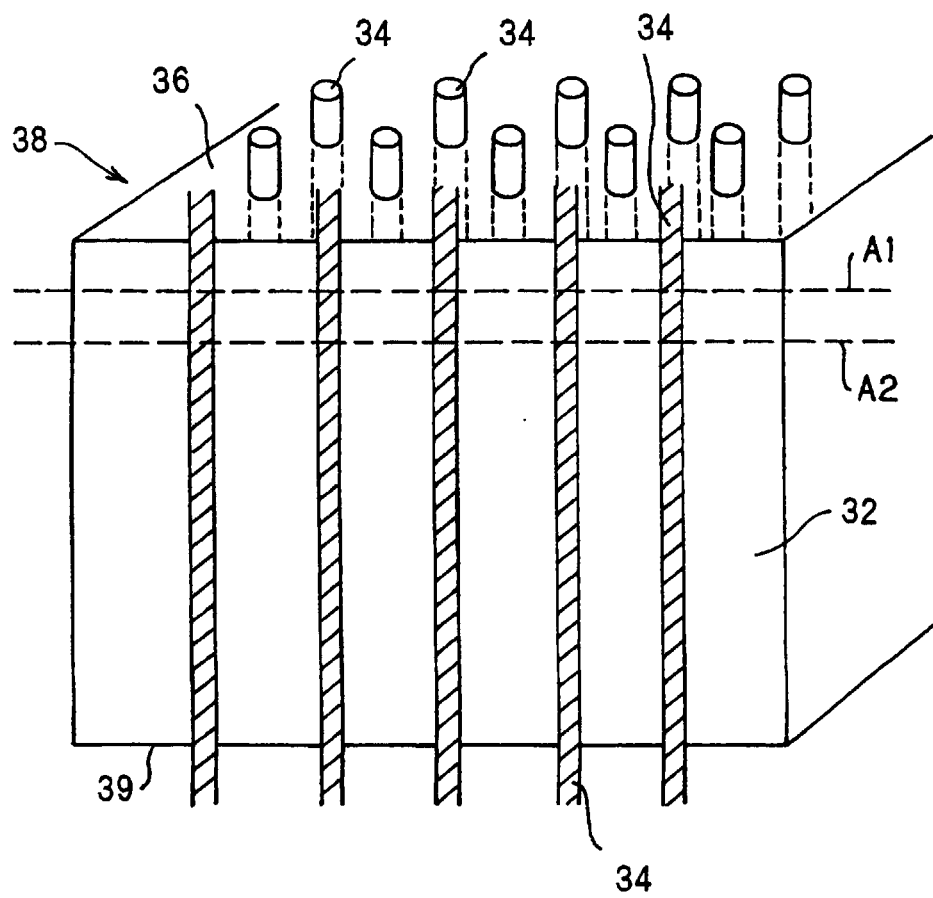


FIG. 15

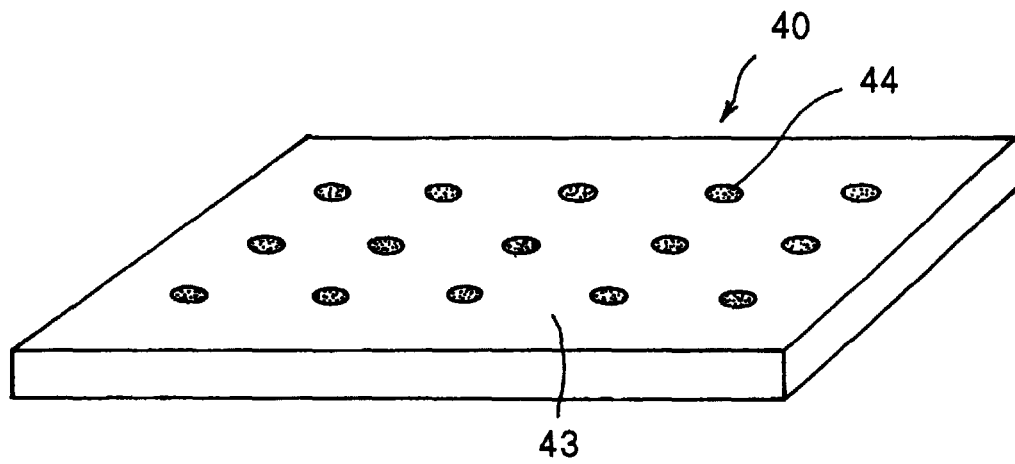
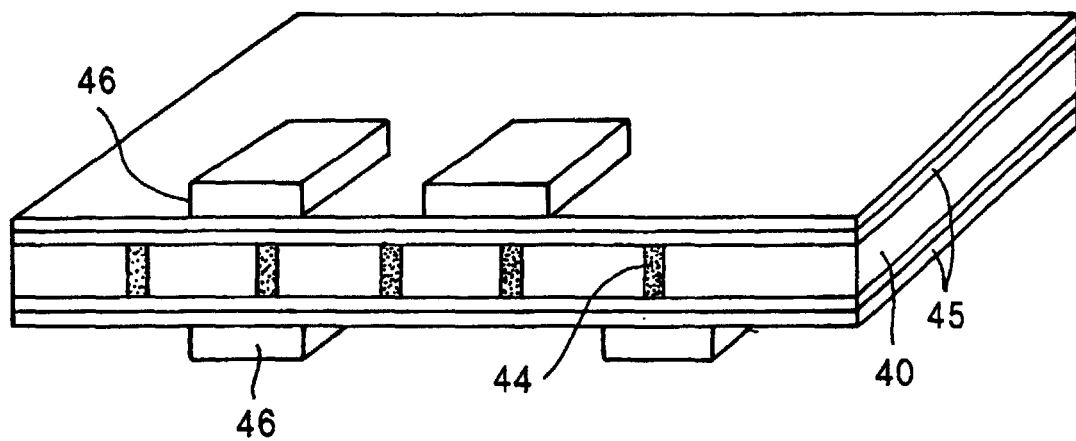


FIG. 16



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP99/05718

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁷ B21F 45/00 , H01R 43/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int.Cl ⁷ B21F 45/00 , H01R 43/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-2000 Kokai Jitsuyo Shinan Koho 1971-2000 Jitsuyo Shinan Toroku Koho 1996-2000		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 59-203385, A (Toray Silicone K.K.), 17 November, 1984 (17.11.84) (Family: none)	1-17
A	JP, 06-076909, A (BRIDGESTONE CORPORATION), 18 March, 1994 (18.03.94) (Family: none)	1-17
A	JP, 08-031873, A (Furukawa Electric Co., Ltd.), 02 February, 1996 (02.02.96) (Family: none)	1-17
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
Date of the actual completion of the international search 11 January, 2000 (11.01.00)		Date of mailing of the international search report 25 January, 2000 (25.01.00)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)